

HFT Simulation Performance

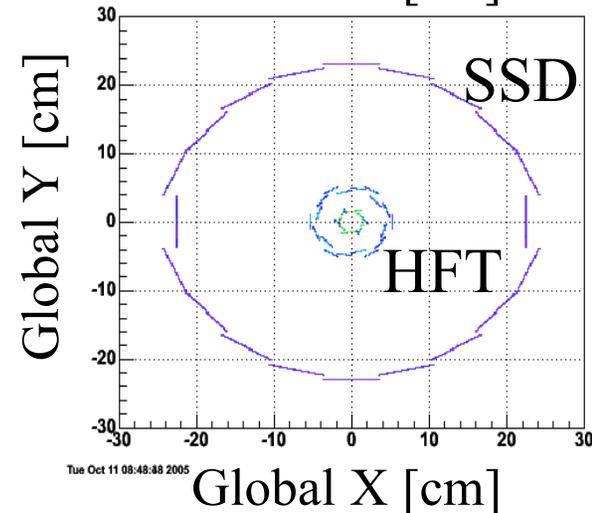
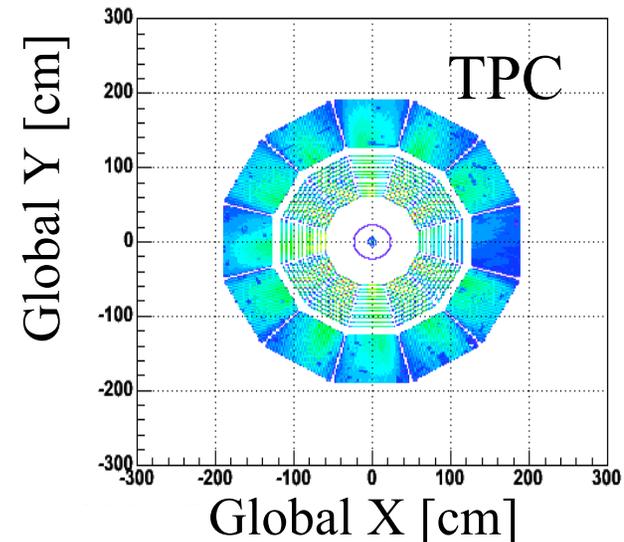
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Simulation Framework

- Simplifying geometric assumptions
 - Electronics and ladder as “extra” silicon
 - Support structure not present
- Use STAR simulation environment
 - Realistic simulation of TPC dead areas and performance
 - SSD and HFT “idealized” with design performance accuracy, perfect cluster finding

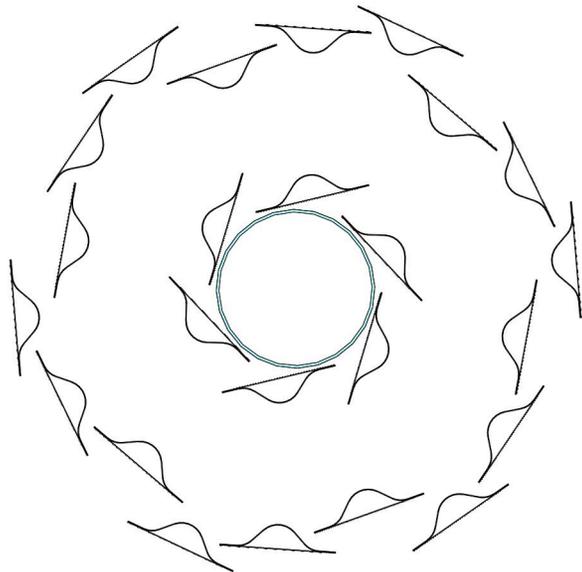
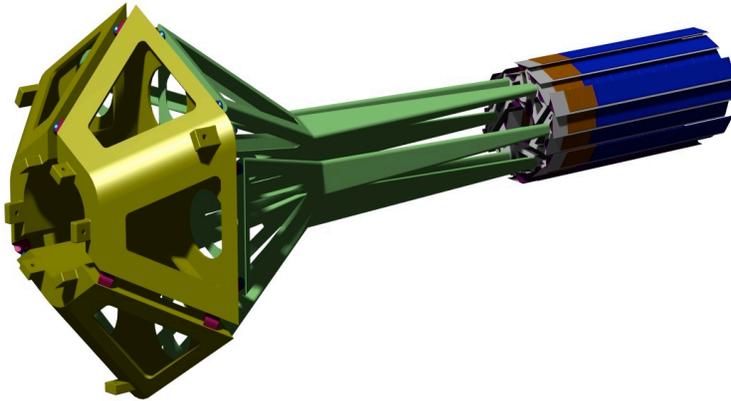
Reconstructed Hits



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Simulation Geometry



Number of ladders	24
Ladder active area	192 mm × 19.2 mm
Number of barrels	2
Inner barrel (6 ladders)	$r = 1.5$ cm
Outer barrel (18 ladders)	$r = 5$ cm
Frame read time	4 ms
Pixel read rate, after zero suppression	63 MHz
Ladder (w/Al cable) % X_0	0.36 % .38%
Pointing Accuracy, σ	$14 \mu\text{m} + 12 \mu\text{m} (\text{GeV}/c) / p$
Beam Pipe Thickness	0.5 mm or 0.14% X_0

Simulated Detector Response

- Detector Resolution
 - $6\mu\text{m}$ hit resolution on GEANT points
(reality $8.6\mu\text{m}$)
 - Only (simulated) source of hit error
- Perfect Alignment
 - No alignment offsets used
- Perfect Cluster Finding (expected $\sim 99\%$)
 - Two particle impact:
$$\epsilon \cong \epsilon_{\text{tracking}}^2 \bullet \epsilon_{\text{cluster}}^4$$
 - Three particle impact:
$$\epsilon \cong \epsilon_{\text{tracking}}^3 \bullet \epsilon_{\text{cluster}}^6$$

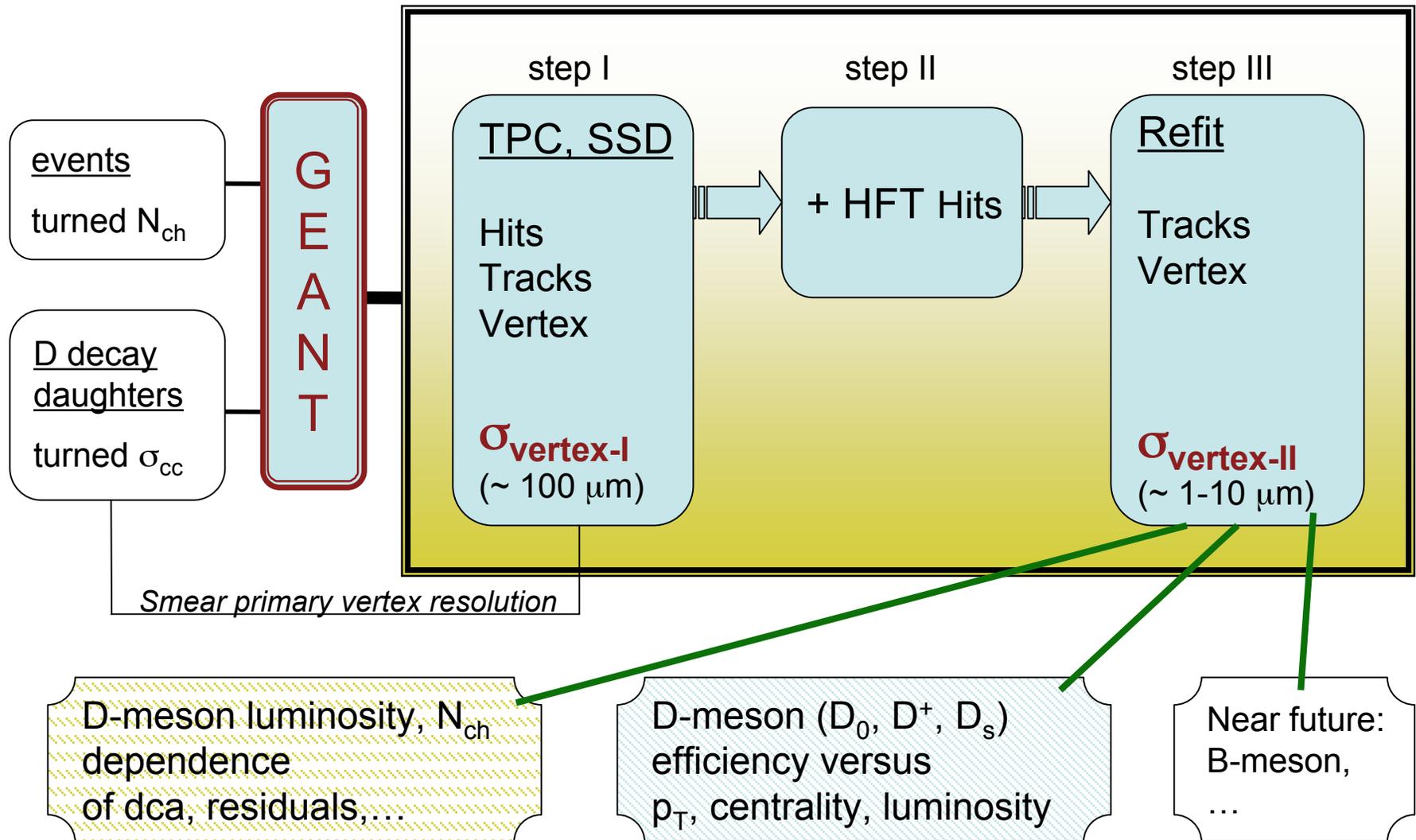


Simulation Environment (Luminosity)

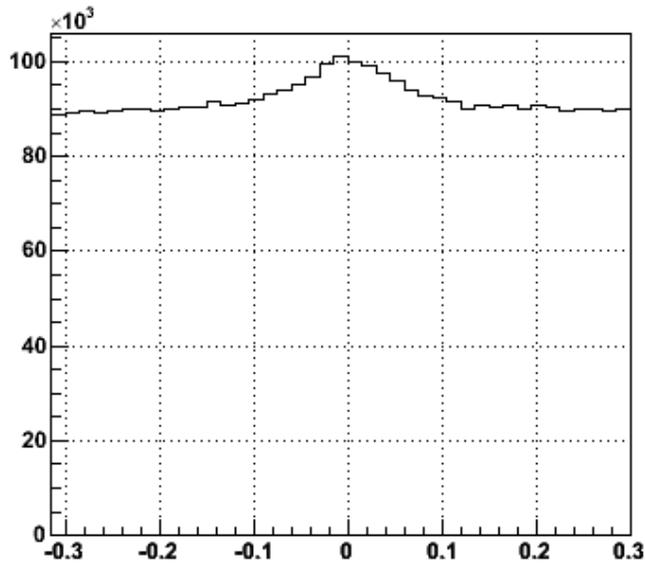
	HFT Outer Layer	HFT Inner Layer
Radius	5 cm	1.5 cm
Hit Flux	4,300 Hz/cm ²	18,000 Hz/cm ²
Hit Density 4 ms Integration	17/cm ²	72/cm ²
Projected Tracking Window Area	0.6 mm ²	0.15 mm ²
Probability of Tracking Window Pileup	10 %	10 %
HFT Hit Resolving Area	0.001 mm ²	0.001 mm ²
Probability of HFT Pileup	0.14%	0.58%



Reconstruction Algorithm



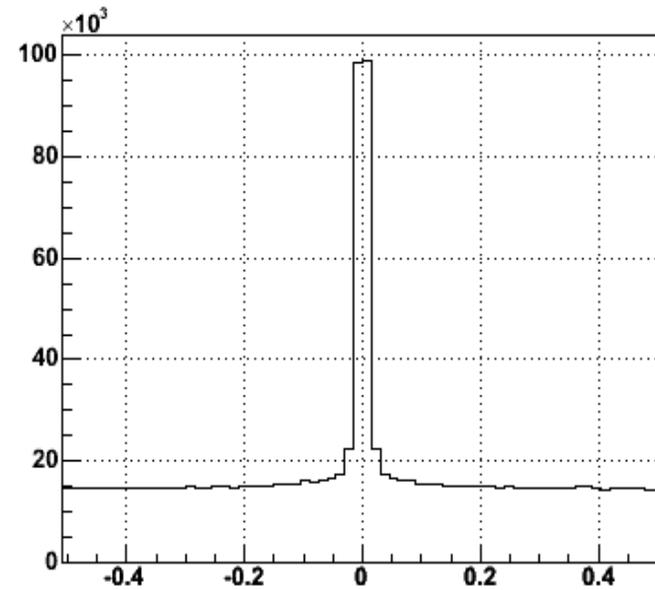
Track to Hit Residuals



Track Y - Hit Y [cm]

TPC+SSD+Vertex

- At Inner Layer



Track Y - Hit Y [cm]

TPC+SSD+Vertex

+1 HFT

- At Inner Layer

Performance Determination

- Hand calculations
 - Methods detailed in the Particle Data Book
- Simulations
 - STAR - GEANT based simulation framework
 - Full tracking & signal analysis to predict results



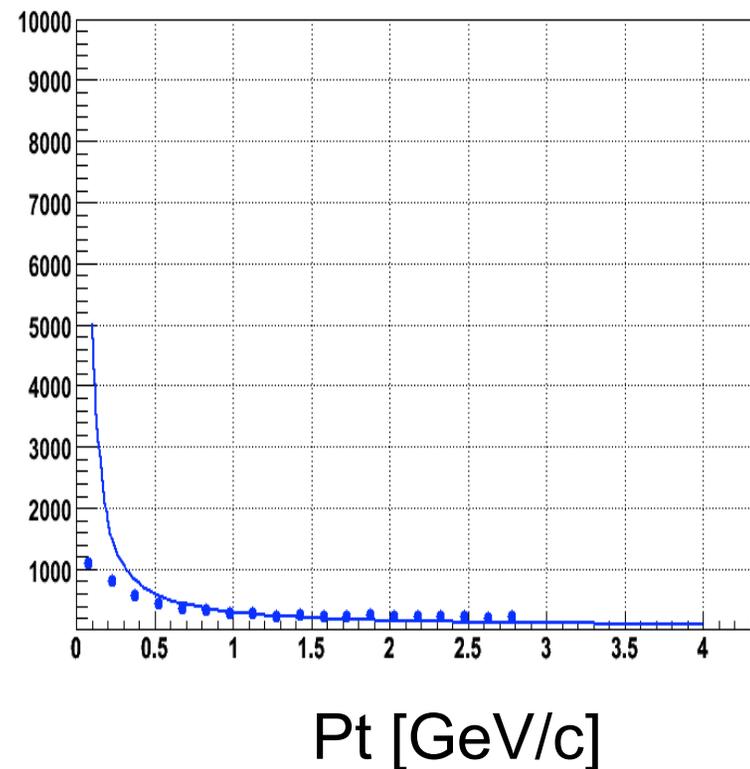
Predicted Performance

- Resolution

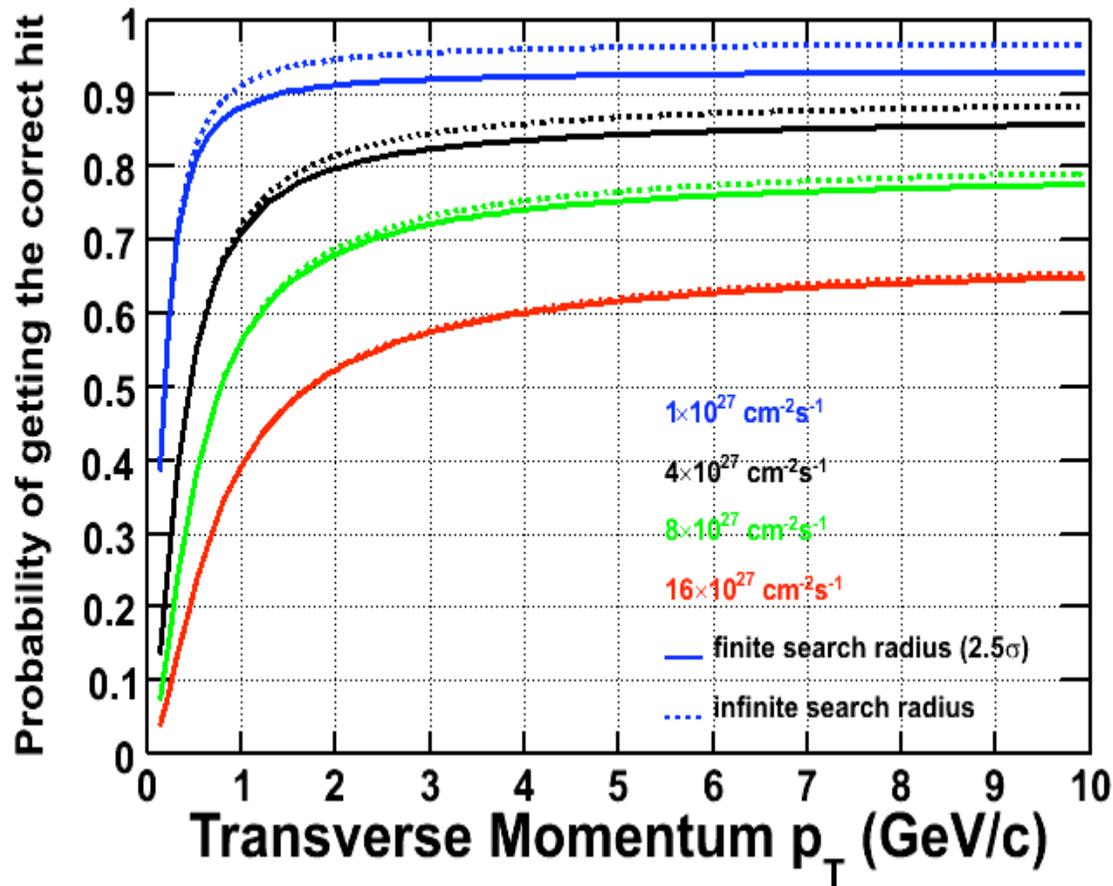


Track to Hit Residuals

- Residuals agree with resolution prediction



Predicted Performance

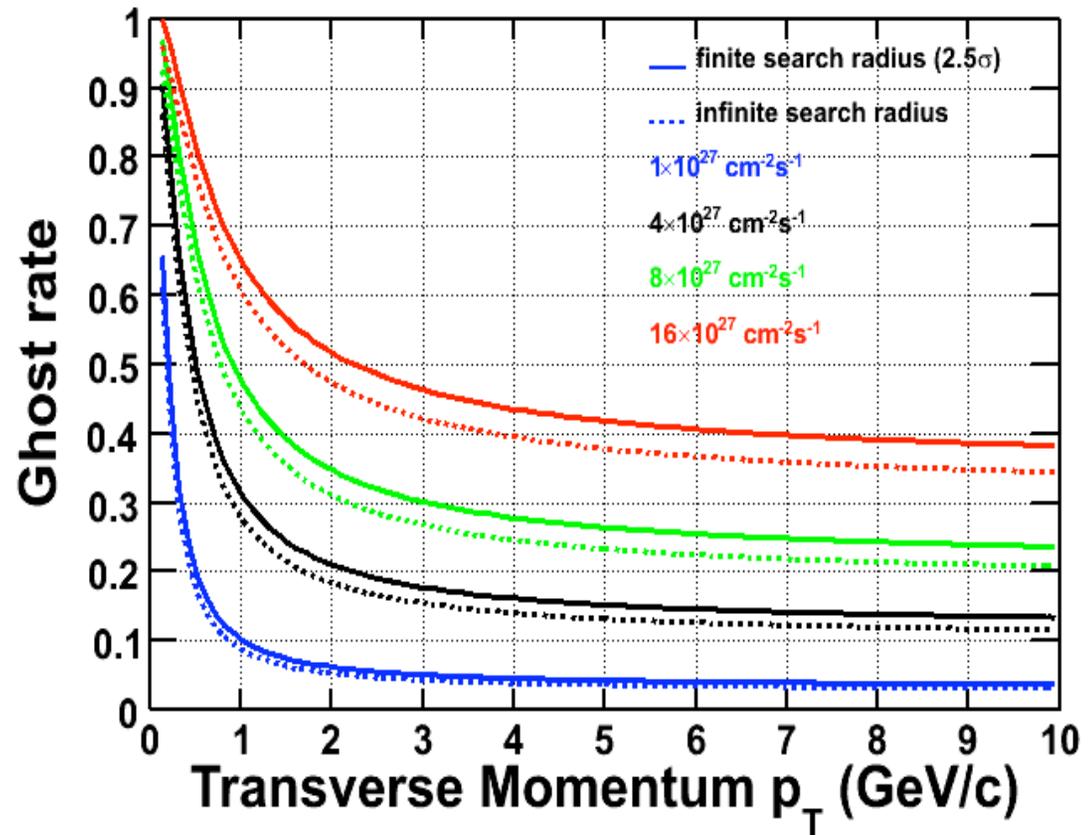


Efficiency for adding correct HFT hit to TPC+SSD Track

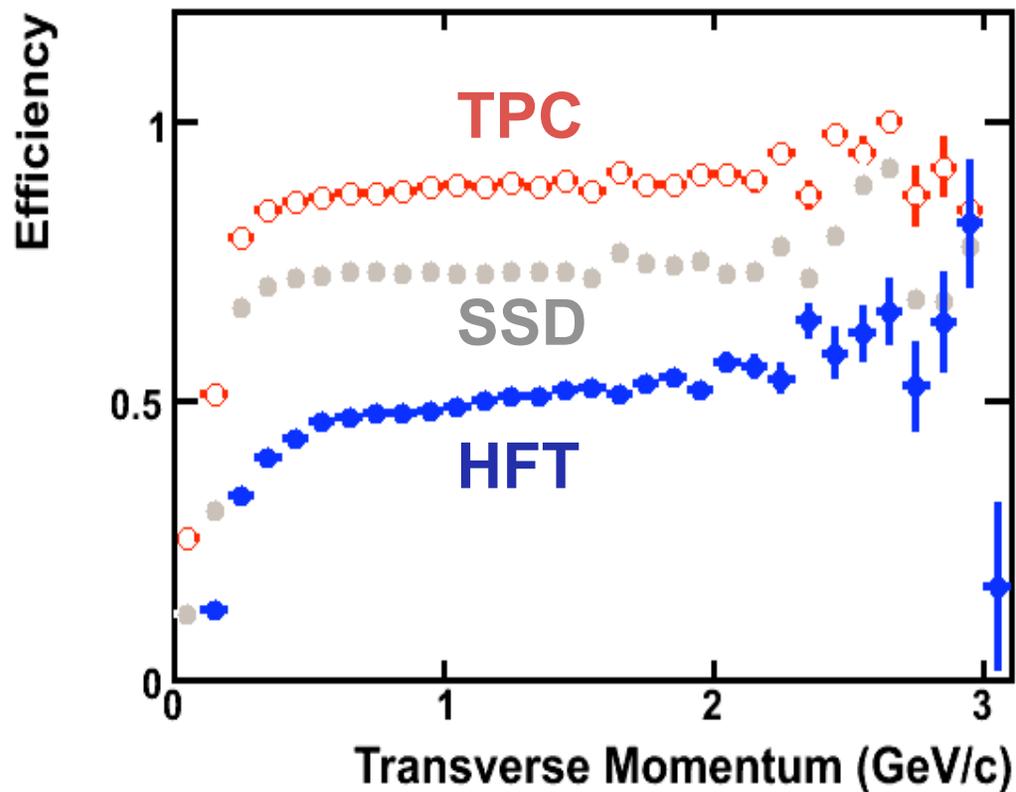
Predicted Performance

Calculated Ghost Rate

- <20% (above 2 GeV/c) for 4x current high luminosity



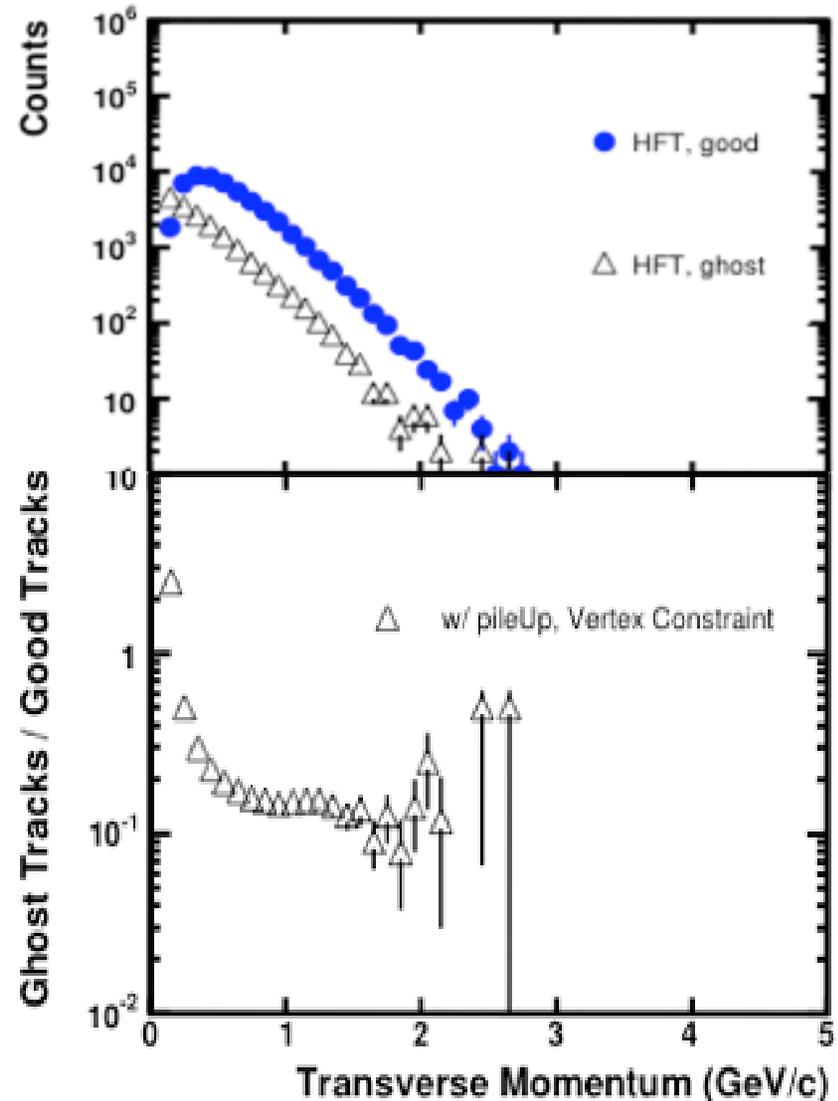
Simulation Efficiency



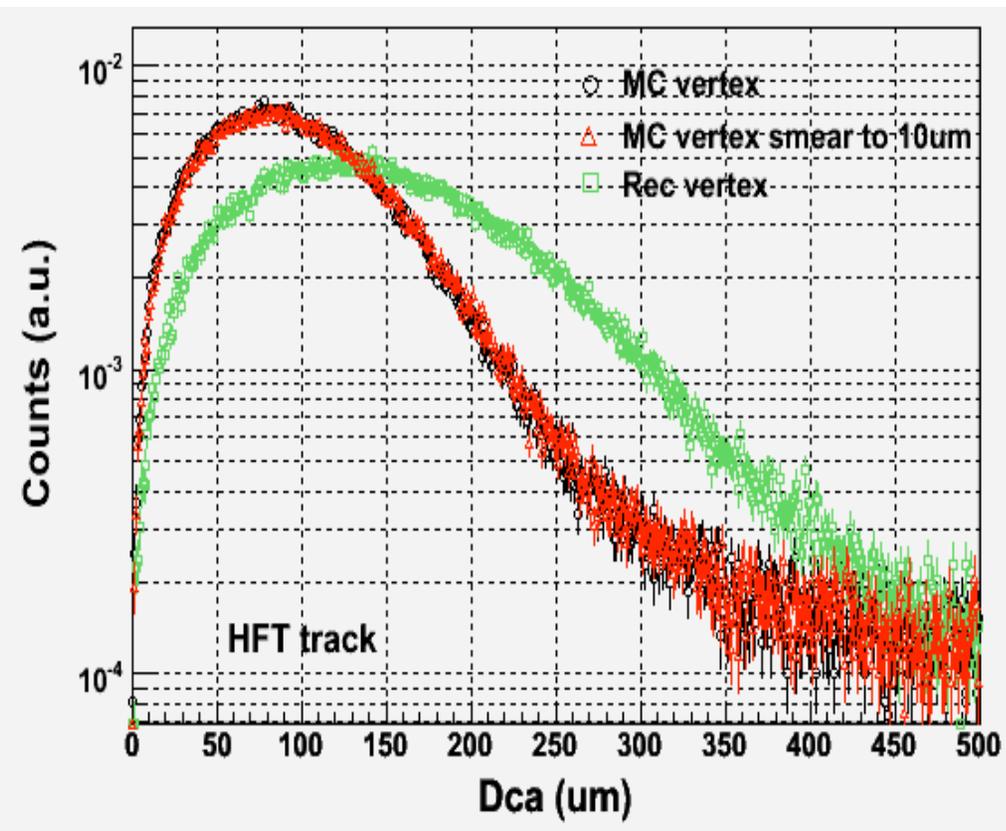
- $\sim 50\%$
 - *total tracks*
 - Candidate tracks, (TPC+SSD) $\sim 75\%$
- Luminosity 1×10^{27}

Simulation Purity

- 1×10^{27}
Luminosity
- 12% Ghosting rate in central collisions
- Higher than expected from calculations



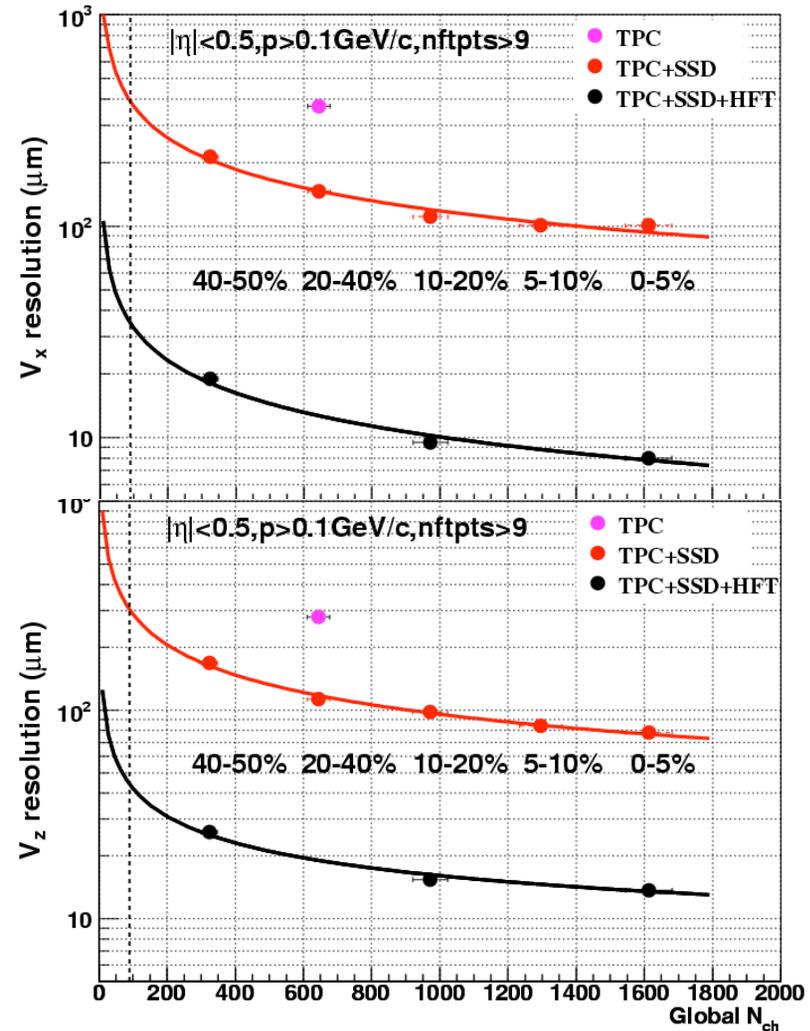
Track DCA



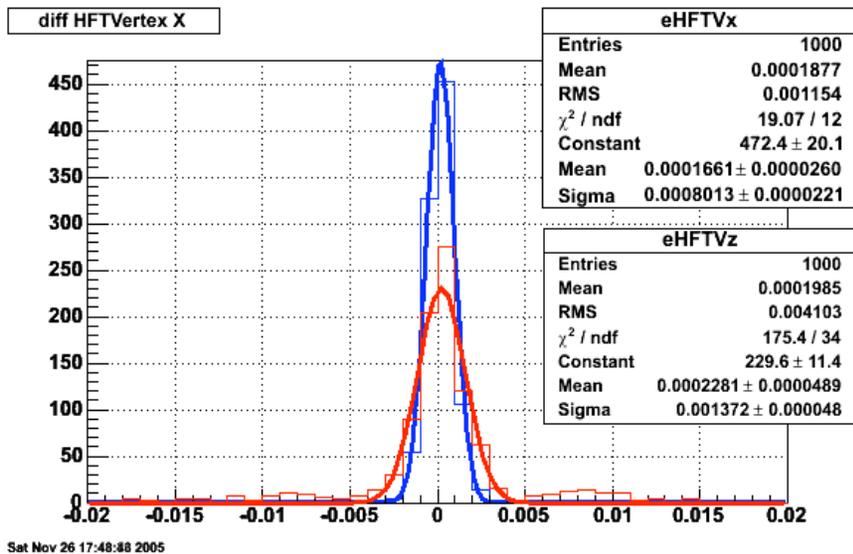
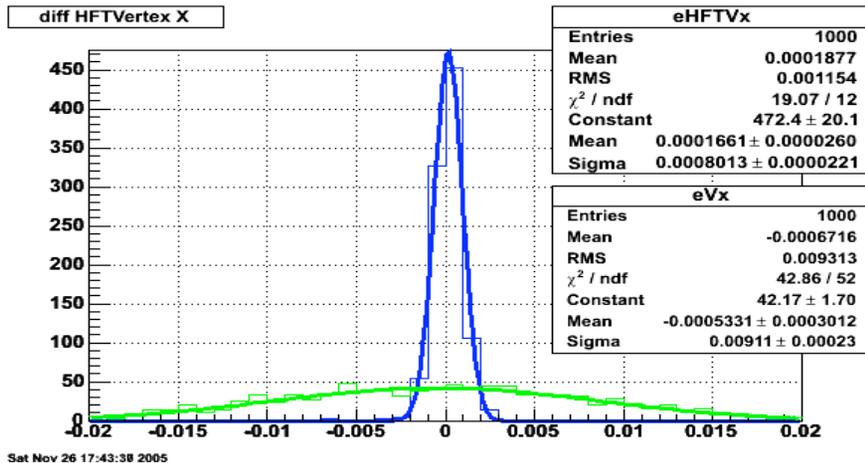
- Hit Finding:
TPC + SSD + Vertex
- Track Fit:
TPC+SSD+HFT
- HFT DCA
 - TPC+SSD Vertex
~110 μ m
 - MC vertex ~70 μ m
 - 10 μ m smeared
vertex ~70 μ m

Vertex Resolution

- TPC+SSD+HFT DCA distribution
 - Non-zero mean used as correction
 - Iteration yields best results
- Final resolution $\sim 8\mu\text{m}$ in x,y
 - Order of magnitude improvement
- TPC+SSD Vertex Resolution sets minimum multiplicity for tracking



Vertex Reconstruction

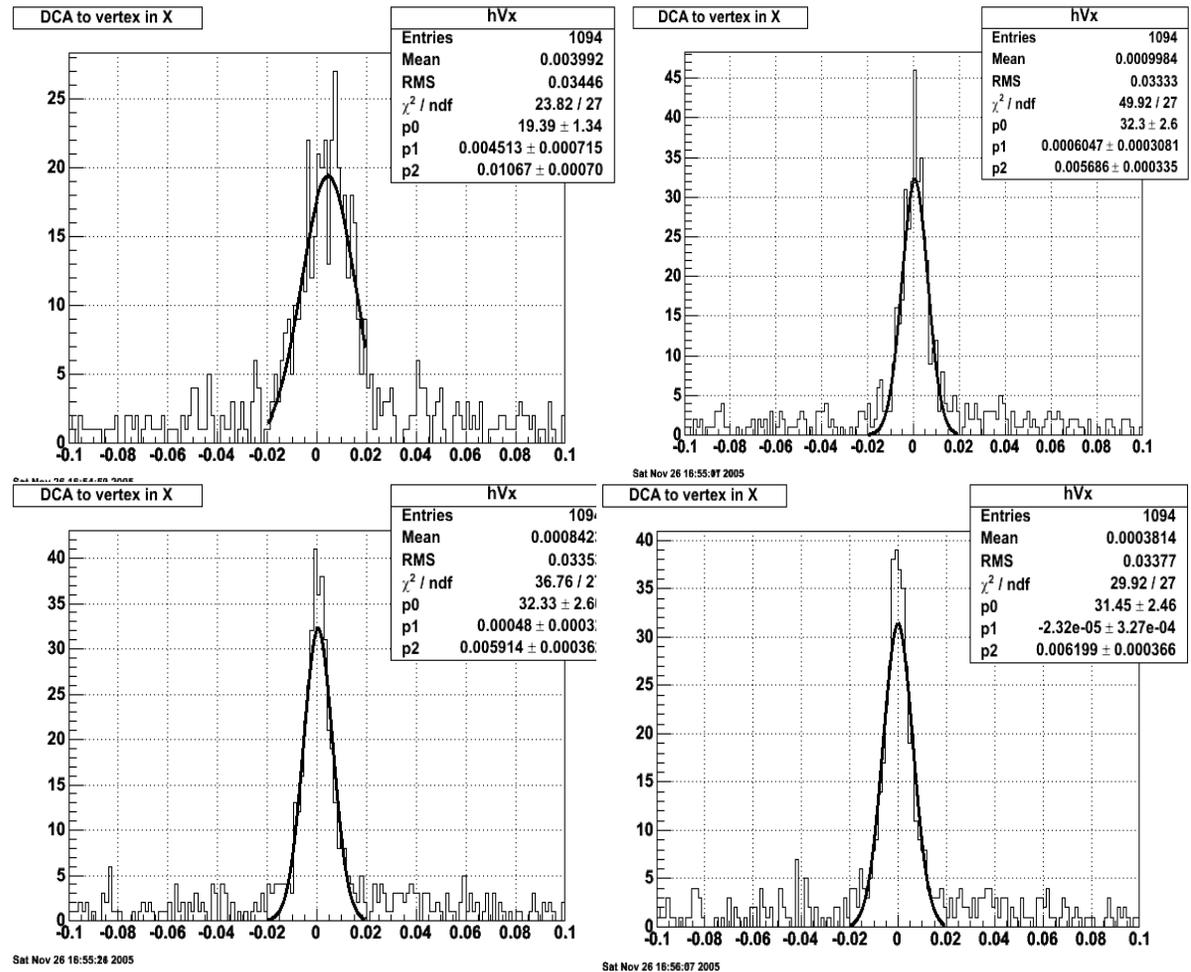


- Vertex resolution in X,Y has Gaussian shape
- Fit poor in Z
 - Peaks at +/- 80 μm
 - 10% of events
 - Iterations driving vertex z away from MC value



Vertex Resolution - Iterations

- TPC+SSD+HFT
DCA distribution
 - Non-zero mean used as correction
 - Iteration yields best results
- Final resolution $\sim 8\mu\text{m}$ in x,y



Heavy Flavor Simulation Method

- Signal and Background simulated separately
 - Signal vertex smearing ($100\mu\text{m}$)
 - Signal corrected for Efficiency
 - Signal rate must be renormalized to expected cross sections
- Track Solution (2 HFT points, track momentum)



Progress since HFT Workshop

- Calculations of predicted performance
- HFT Vertex resolution estimate
- D⁺ study (3 body decay)
- Signal studies using reconstructed vertex



Focus for the Future

- Hand calculations predict better performance than seen in simulation.
- Momentum resolution determination
- Chain integration

- Physics: Ds, B



Conclusions

- Resolutions for track and vertex meet expectations
- Charged Tracks
 - Efficiency 50%, Purity 12%
 - Centrality range 60%-0%
- Vertex Resolution

$$\sigma = \frac{380\mu m}{\sqrt{N}}$$

